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DESIGN AND FABRICATION OF ALL WELDED BRIDGE CRANES

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AS manufacturing processes have become more complex and straight line production the rule rather than the exception, the electric traveling bridge crane has become a production tool. Equipment of this nature is subjected to continuous service, making it essential to reduce maintenance to a minimum, increase efficiency, eliminate costly production delays, and in many cases to use speeds which only a few years ago were considered impractical. While safety is always important, it is doubly so in the case of a crane since it is always in operation over workmen's heads. The development of roller bearings and application of welding to crane construction has enabled these demands to be met.

The conventional crane design which has always been followed, for many years consisted of riveted box girders, heavy cast end trucks and cast trolley side frames and heavy structural members which were either bolted or riveted together. The modern welded design provides a welded box girder with end trucks and trolley frames completely welded of structural shapes into two separate monosteel units.

In order to illustrate the evolution from the old riveted method of construction to the modern method of weld-

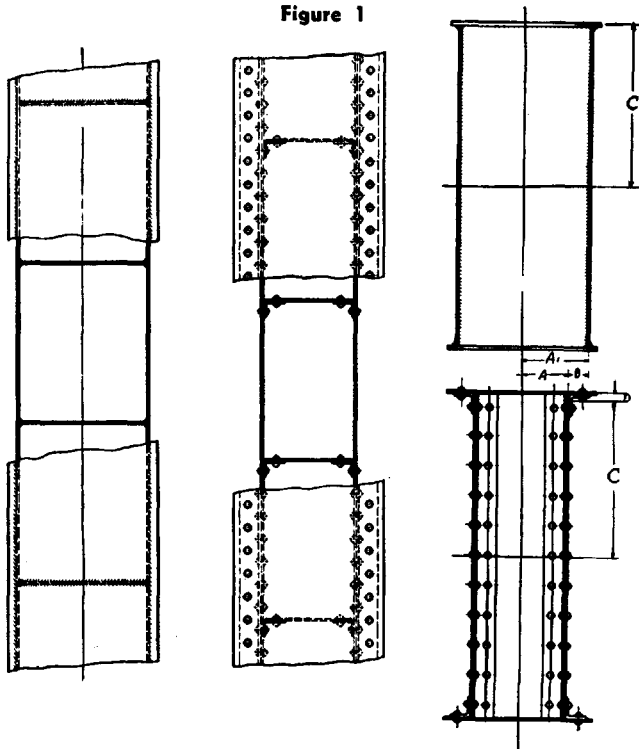
ing, we will take up separately the principal units which go to make up a complete crane,—namely, (A) the bridge girders; (B) the end trucks and (C) the trolley frames.

The bridge girders are usually the largest and heaviest part of a crane, and always the longest unsupported members. In the design of a girder, resistance to deflection is of course essential. But in modern high speed cranes, the factor of rigidity has become so important that the welded girder will eventually completely replace the older type. A box girder consists of a top and bottom cover plate and two web plates with diaphragms located at frequent intervals along the girder. In the riveted design, the cover plates are attached to the web plates by chord angles and the diaphragms attached to the web plates in the same manner. In the welded design, the web plates are attached directly to the cover plates by fillet welds, the chord angles being eliminated. It is also possible to attach the diaphragm to the top cover plate as well as the web plates, a feature of design impossible with riveted construction.

Figure 1 illustrates clearly the difference between the two types of construction. Every time a rivet is used it means the strength of the parts to be joined is reduced in an amount equivalent to the size of the rivet hole. Fabricating by welding employs the full strength of the contiguous parts, so from a design standpoint, the gross section is the net section. It follows therefore that adequate strength can be obtained with less material, resulting in a reduction in gross weight which is vitally important, and seems to be one answer to the question so often heard, "Why drag around a lot of dead weight for 25 years?" As bridge speeds have increased, the girders are required to absorb the greater impacts, the higher acceleration forces and stresses, resulting from bringing the crane to a quick stop. All these forces tend to loosen rivets, resulting eventually in mis-alignment and high maintenance costs.

It can be seen from figure 1 that in the welded girder the web plates can be placed further apart with a given width cover plate than is possible with the riveted girder, and since the chord angles have been eliminated, the distance from the neutral axis to the center of gravity of the cover plate is increased by an amount equivalent to "D". It is obvious that this produces a stronger and more rigid section by being able to utilize the material to give the greatest stiffness and strength with the minimum deadweight and greatest mechanical strength per

Figure 1



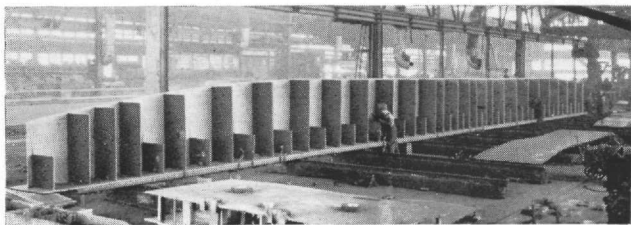


Figure 2

pound of metal. The trolley wheel load is imposed on the girder through the rail which is mounted on the top cover plate. Since the diaphragms are welded to the underside of the top cover plate, this load is carried directly to the girder section by means of the diaphragms. Since it is impossible to rivet the diaphragms to the cover plate, this load may not be properly distributed, which results in subjecting the cover plate to severe additional stress caused by deflection. For the riveted girder as a whole, this becomes a weaving action that grows more pronounced with the service life of the crane, and as the weaving increases the girder weakens. This sagging and weaving cannot occur in a welded girder, because all points are rigidly connected, with no possibility of the cover plate slipping at the diaphragms. The welded construction produces a cell-type girder with the top plate rigidly connected to all four sides of each cell, (i. e. to both web plates and to two reinforcing diaphragms). This construction is of extreme importance, because all connecting edges of each cell are rigidly joined, except two—i. e. between the diaphragms and the bottom plate. Each cell, therefore, will resist stresses and shocks in every direction,—horizontally, vertically, or diagonally. For this reason, a welded girder, with its many component cells, will withstand strains and skewing and twisting action to a far greater extent than is possible with a riveted girder, and what is more important, the actual deflection of a welded girder under load can be accurately computed, this has been proven by tests. The amount of slippage in a riveted connection depends on so many factors that the deflection of a riveted girder cannot be computed with any degree of accuracy.

Figure 2 shows a 120' span welded girder in the process of fabrication. All welded girders are airtight and watertight, this gives a permanent resistance to interior corrosion, which is another feature impossible

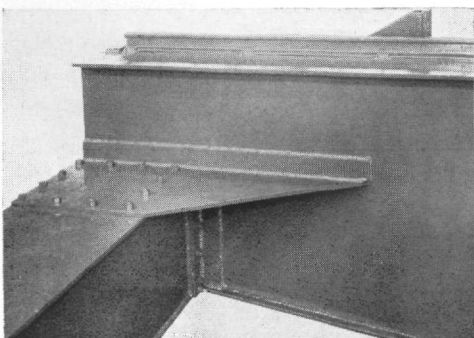


Figure 3

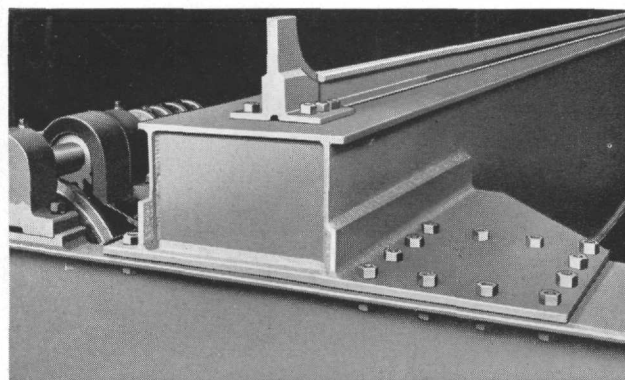
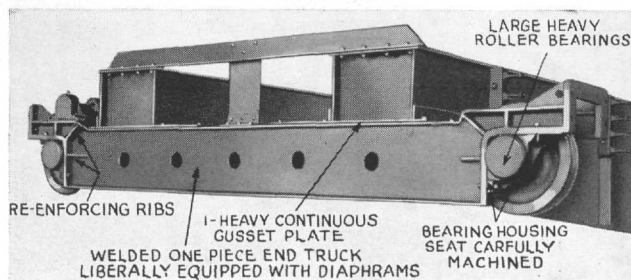


Figure 4

to obtain with riveted construction.

The two bridge girders are supported and connected together at the ends by heavy end trucks, in which are mounted the crane wheels. Next in importance to a rigid girder for maintaining alignment is the connection of the girders to the end truck. Consider for a moment the forces involved when a long span, high speed crane, with its trolley located at one extreme end and fully loaded, is either accelerated to full speed or brought to a quick stop. The unloaded end naturally tends to come up to speed faster or come to a stop quicker. This skewing action, unless properly resisted, would quickly result in mis-alignment, causing excessive maintenance of all machinery. Welded design offers the best solution to this problem. The ends of the girder are notched during fabrication,—see Figure 3. During assembly the end truck and girder are lined-up before the end tie connection is made. The final result is clearly shown in Figure 4. In the design of any large welded structure, it is important to make adequate provision for the adjustment which is essential in final assembly to take care of any distortion and shortening due to welding. A good illustration of this is provided in the end tie connection. A wide gusset plate is first bolted to the end truck. This gusset plate extends through the notch of the girder. Regardless of the amount of gap between the web plates of the girder and the gusset plate, a positive and permanent connection is made by welding the webs and gusset plate together by means of a long horizontal shear bar which can be clearly seen in Figure 4. Figure 3 also shows how this type of welded connection is applied in attaching the end of the girder to the side of the end truck. After welding, the gusset plate be-

Figure 5



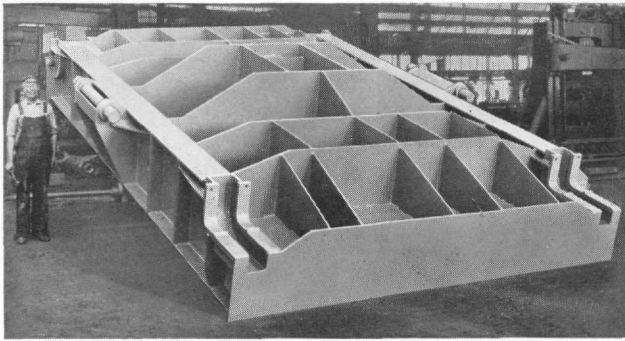


Figure 6

comes a permanent part of the girder. The assembly in the field is simple, and permanent alignment of the girders is assured.

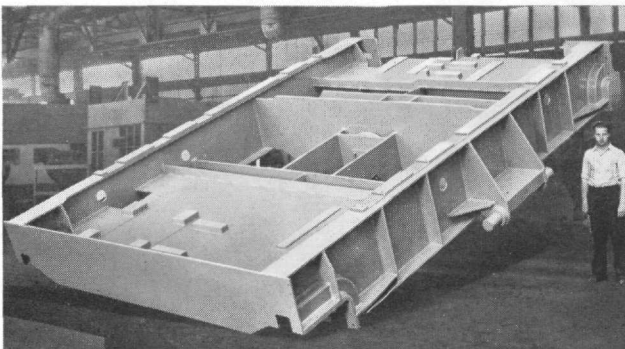
The end truck, which is shown in Figure 5, is constructed in much the same way as the girders. The box section is made up entirely of rolled steel plates and shapes, including the proper number of interior stiffening diaphragms. The wide surfaces of the trucks are designed to accommodate the gusset plates of the notched girders. The older method of end truck construction was to use a one piece casting. The problems of casting a long end truck, due principally to the abrupt changes in section, required the use of a far heavier section than necessary. The principal source of weakness in a cast end truck occurs at the bearing seats in the notched end. In the welded truck, the bearing seats are made from rolled steel of known strength which can easily be strengthened by reinforcing ribs located so as to absorb the shocks and loads from all directions.

Welding enables the designer to ignore the limitations of the foundry, an advantage so great that it is hardly necessary to elaborate on it.

The hoisting machinery of any crane should be mounted on as rigid a base as can be constructed within the limits of clearance and mobility.

Welded trolley frames are rolled steel sections welded into one complete unit. (See Figure 6.) During fabrication, parts of the trolley frame are welded separately. Final assembly is then obtained with a minimum amount of welding, keeping the locked up stresses to a minimum, because welding distortion and shrinkage has already taken place in the component parts. Here again the de-

Figure 7



signer can easily provide for this factor as was possible in the connection of the girders to the end trucks.

Where machinery is to be mounted, (See Figure 7,) structural members are thickened by suitable pads, so that through bolts will have ample bearing area.

After the welding is complete, the trolley frames are carefully machined as one piece units, so that accurate centers of gears and shafts will be permanently maintained. No flexible couplings are used. Where mis-alignment does not, and cannot exist, it is unnecessary to provide for it.

The desirability of applying roller bearings to heavy machinery introduced a problem that demanded a new type of machine assembly. The precision bearing made up of tolerances in the magnitude of ten thousandths of an inch, required an overall assembly of machinery within the same tolerances, otherwise damaged bearings and races would cause the immediate failure of the whole machine. Prior to that time, slight mis-alignment of parts had frequently gone unnoticed because it had no

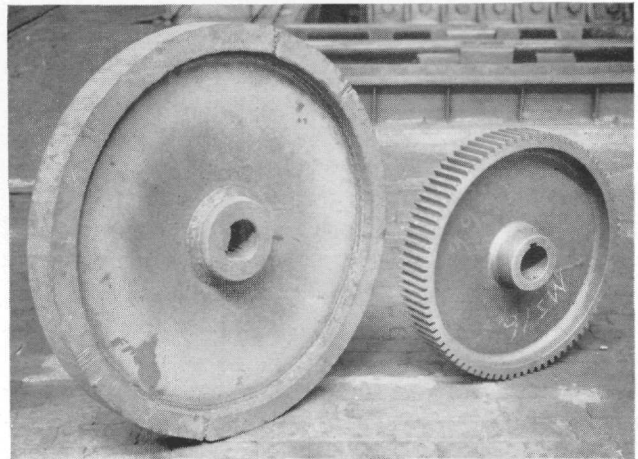


Figure 8

serious consequence. The bronze bearing could wear itself in such a manner as to accommodate minor distortions. If gears chattered and journals and bushings showed excessive wear, and had to be replaced, it was considered a necessary evil. The welded structure is the obvious solution to the problem.

Note the many stiffeners and braces welded and becoming part of the one piece steel structure, and since it would be necessary for the foundry to produce a one piece casting to be comparable, it is not hard to imagine the many difficulties. Attention is also called to the location of the double acting spring bumper welded on each trolley side frame. The shock of striking the end stops is transmitted through the side frame rather than through the wheels and bearings.

In welding, generally we are able to use worked steel with known analysis and consistent strength. The fact that shapes and plates are rolled, produces a quality of material which can never be obtained by a casting. Different types of rolled steel can be used where special qualities of material are required. A notable example of

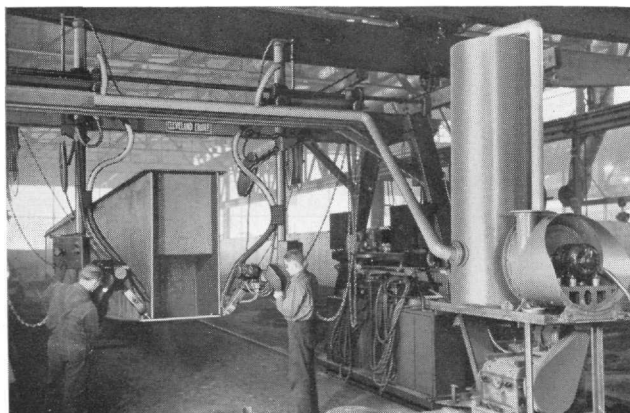


Figure 9

this is a welded gear. See Figure 8. The rim of the gear is high carbon steel to provide the resistance to wear and long life of the teeth so desirable. The web and the hub can be of lower carbon content, providing the necessary shock absorbing qualities also desired. It must be kept in mind that it is necessary to anneal high carbon material that has been welded. Many times a cast steel gear blank will be almost completely finished before inherent flaws in the casting show up. While with rolled steel material the resulting welded gear is homogeneous throughout.

The rapid improvement in welding electrodes, providing a weld metal of 20% - 25% elongation, consistently, enables the designer to take full advantage of his materials. Proper welding equipment for the job is essential, and in many cases the successful fabrication of a welded structure requires special equipment. A good example is shown in Figure 9, which shows two automatic welding heads mounted on a motor driven gantry crane,—one located on each side of the girder, making the two fillet welds simultaneously, which connect the bottom cover plate to the two web plates of a crane girder. The speed of crane can be varied to suit the work.

A simple illustration of the advantage of welding in design is shown in Figure 10, showing a welded bridge line shaft bracket. The bracket consists of two plates and a channel section. The two plates are welded to the web plate of the girder. The bearing housing is bolted to the channel for easy removal. During assembling the shaft and bearing are properly lined up, after which the channel is securely welded to the two plates. The parts always remain in place, eliminating the possibility of misalignment of the line shaft. Maintenance of line-shaft bearings therefore becomes little more than lubrication.

In the case of the bridge crane, which has been described in this article, attention is called to the extensive and almost exclusive use of fillet welds. Structural shapes and plates come from the mill true to shape within established mill tolerances. The use of fillet welds enables the welding designer to ignore these irregularities to a large extent.

The freedom from limitations on the welding designer is so great that, in effect, the modern weldery is in the position of being able to fabricate complicated mechanical structures, by means of acetylene torch, shear and welders almost as easily as if the raw material were wood, rather than rolled steel.

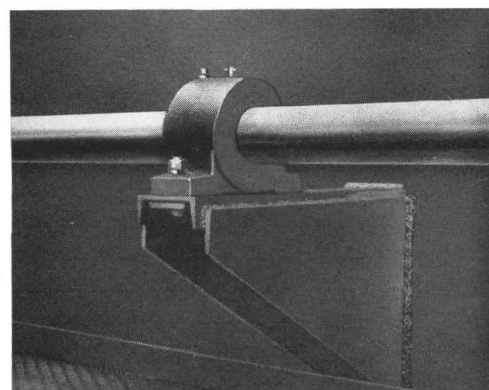


Figure 10